THE SCENE AT SEAFORTH BRIDGE. THE MAIN SOUTHPORT ROAD (SEEN ABOVE) WAS FLOODED FOR A CONSIDERABLE DISTANCE (see p. 132).

[*Reproduced by kind permission of the Liverpool Observatory and Tidal Institute.*]

*facing p.* 129

M.O. 359.

# The Meteorological Magazine

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## The Thunderstorms of June, 1933

June in England was remarkable for the persistence of thunderstorm conditions through the greater part of the month. Taking as a basis the stations for which data are published in the *Daily Weather Report*, thunderstorm or thunder heard was reported on no fewer than 17 days, including every day from the 14th to the 26th inclusive, while lightning without audible thunder was reported on several other days.

A sketch of the distribution over the country of days with thunder heard is shown in Fig. 1. This is necessarily rough as it had to be drawn on July 1st when the material available was scanty, but it suffices to show two main areas of frequency, one over London and west-south-westwards to Hampshire (Greenwich 6, South Farnborough 7, Winchester 6), and the other over the Midlands (Birmingham 8, Cranwell 6, Ross-on-Wye 6). From Lutterworth in this area Mr. M. W. Binns wrote on June 22nd: "Twelve thunderstorms have been experienced within a radius of six miles, several passing over Lutterworth, within the last ten days."

June opened with an anticyclone over western Europe and a shallow depression over the eastern North Atlantic. The British Isles lay in the course of a southerly or south-easterly current and temperatures mounted rapidly, but thunderstorms developed only on the south-west coast and in the Channel on the 3rd,

(2384) 32/91 1,000 7/33 M. & S. *Gp.303*

under the influence of a secondary depression over the Bay of Biscay. Subsequently the anticyclone extended over the British Isles, and on the 8th the centre lay to the west of Ireland, with a northerly current over England. Storms developed on this day in the north-west and Midlands. In Buxton, according to the *Daily Dispatch*, a violent storm broke shortly after 4 p.m., an inch of rain falling in a short time. The wooden blocks of two main roads swelled up and burst. In Manchester, according to the *Manchester Guardian*, the storms began about 3.15 p.m. and continued for three-quarters of an hour with violent rain. Houses were struck and set on fire or otherwise damaged, while several tramway standards were destroyed, the fuse-boxes being melted. In one case the heat developed was so great that the metal of the standard itself became half molten, causing the upper part to bend over. In Kingsway the water was 18 inches deep. Two occupied telephone booths were said to have been struck, and in one case the occupant was thrown into the road, but there were no serious injuries associated with the storm.

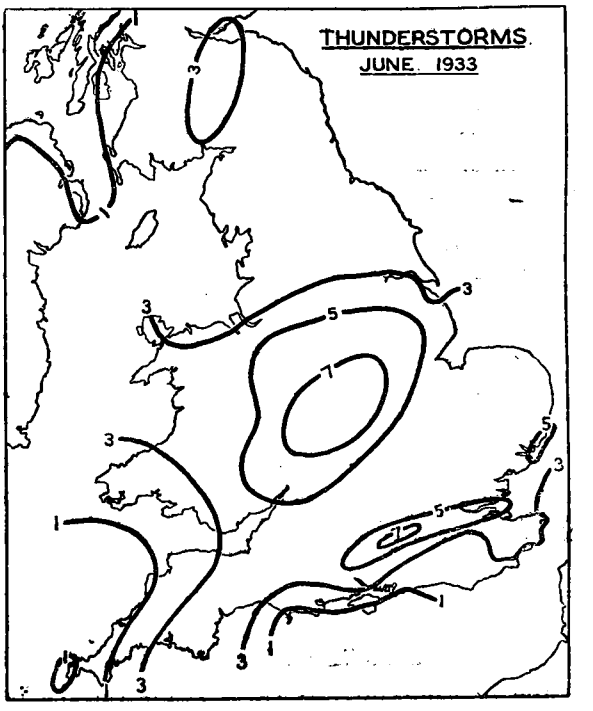


FIG. 1.

With a similar pressure distribution there were storms in a few places on the 9th and 11th. On the 12th pressure became more uniform; isolated storms developed on the 14th and became more numerous on the 15th, when the London area was struck. During a storm on the latter day at Ovington Rectory, Hants., 2·37in. of rain fell in an hour. On the 16th the British Isles came under the influence of a deep depression over the Faroes and a series of violent storms occurred on the 17th, especially in the Midlands, east and south-east England. At Ipswich 0·52 in. of rain and hail fell in less than half an hour, and slight flooding occurred. Snow was reported on this day at Giggleswick, in Yorkshire, W.R., and at Bellingham, in Northumberland. On the 18th and 19th the depression passed across England, and in its rear on the 19th

thunderstorms developed over the greater part of the country, including London. In Epping Forest two men were killed and two injured among the trees, and a man was killed and another injured at Woolwich while running for shelter. Several houses were also damaged. Hail caused damage to fruit trees in Kent; in some places the hailstones lay four inches deep. At Foxbury House a large fir was shattered by lightning, parts of the trunk being thrown nearly a hundred yards.

The storms continued on the 20th, the most noteworthy being a " cloudburst " at Bootle, a description of which by Mr. H. J. Bigelstone follows this general account. On the 21st a new depression developed over England, and the Midlands and Wales again suffered. Two youths sheltering under a tree near Port Talbot were injured by lightning. At Garstang, in sunny calm weather, large quantities of new-cut hay were seen floating about in the sky, probably as the result of a whirlwind in the neighbourhood. As the depression filled up and passed away storms were again general on the 22nd, especially in south-east England and the Midlands. Many buildings were damaged, and three men were killed. Two of these were sheltering under trees; the third was near an iron railing. A waterspout was said to have occurred near Folkestone, with heavy rain and hail. The main Canterbury-Folkestone road was flooded to a depth of over a foot, while the wooden paving was forced up and cellars were flooded at Dartford in Kent. Another man was killed under a poplar tree in Gloucester.

On the 23rd, 24th and 25th, the pressure distribution over England was nearly uniform, and the storms were more scattered, though London was visited again on the 24th. On the 26th an anticyclone approached from the Atlantic, and a final series of storms developed in south-east England and the Midlands. After this the high pressure spread across the British Isles and fine weather set in and continued to the end of the month.

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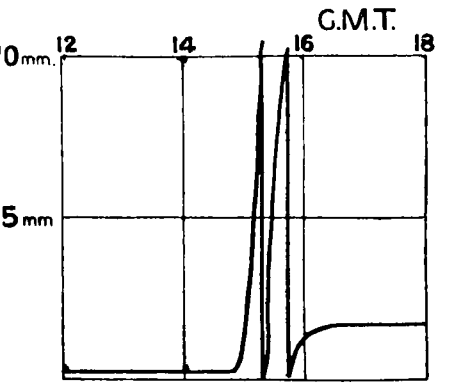
## Thunderstorm on Merseyside, June 20th, 1933

By H. J. BIGELSTONE,

*Principal Assistant, Liverpool Observatory and Tidal Institute.*

During the week of June 18-24th the Merseyside area experienced a number of thunderstorms of which one, on the afternoon of June 20th, is stated to have been the worst ever experienced in the area since 1918. The storm appears to have travelled from North Wales passing over Birkenhead and Wallasey, and finally over Liverpool, in the Bootle, Litherland and Seaforth districts where its greatest violence was reached.

At the Liverpool Observatory, Bidston, thunder was first heard from a southerly direction at 3.12 p.m., followed by vivid flashes of lightning and a torrential downpour of rain. Between 3.45 and 4.45 p.m., 23mm. (0·90in.) of rain were recorded. The wind backed from NW. to WSW. at 3.45 p.m., freshened in a slight squall, and then fell to a calm. A fall in temperature of 12° occurred between 3 p.m. and 4.30 p.m. The storm appeared to be directly overhead at 4 p.m. and was followed by a second and less intense storm. Thunder was last heard at 5.30 p.m.



Record of rainfall at Liverpool (Bidston) on the afternoon of June 20th.

At Corwen, in North Wales, the rain, described as terrific, preceded a storm of hailstones like marbles, and a pronounced drop in temperature was reported. Streets were flooded for some time, due to drains being choked by loose gravel washed through the grids by surface water.

No hail was reported at Bidston, but within an area of less than one mile from the Observatory curious freak occurrences were reported. In Birkenhead one of the main thoroughfares was completely dry, while adjacent streets were flooded. Two houses a mile apart were struck by lightning, almost at the same moment, and by a coincidence the occupiers of the two houses were related. During the storm the control box of a Birkenhead tramcar was fused, the driver receiving slight burns but remaining in control of the car, which was temporarily out of commission. At the Observatory, although there was no actual evidence of lightning striking, light fuses were blown and a telephone switchboard coil was burnt out.

In Wallasey the promenade and main streets were heavily flooded and at least one house was struck by lightning. A residence in West Kirby was also struck. The central part of Liverpool escaped with little more than a shower, and in Wavertree and the south end of the city there was very little rain. In Bootle and Seaforth the violence of the storm and the widespread devastation caused by the floods were such that the scenes on the Birkenhead side of the river were dwarfed into insignificance.

The greatest severity of the storm was confined to a small area of Bootle, only a few feet above sea level and surrounding

Violet Street, Akenside Street and Irvine Street. A resident of one of these streets described the floods as descending in a solid wall of water several feet in height from the surrounding higher ground. In Akenside Street, Bootle, the water reached a depth of over 10ft. swirling and eddying down a steep slope and sweeping under a railway bridge. A youth who was trapped by the waters at this point was swept from his cycle, carried away by the torrent and drowned. His body was only recovered after prolonged dragging operations by the police. A second fatality was directly due to the storm, an elderly man hurrying to shelter collapsing and dying from heart failure. People in the Akenside Street area stated that the sky went inky black, and after violent claps of thunder and vivid lightning flashes, the district was lashed by storms of rain and hail, the hailstones being described as being as large as small hens' eggs. An observer, recently home from India, describing the cloudburst, said: "It was without exaggeration typical of an Indian monsoon. A rapid series of lightning flashes and thunderclaps was followed by the cloudburst, the rain being as torrential as in the Punjab."

Local traffic in the Seaforth-Bootle area was entirely disorganised. Motor cars were stranded in attempting a passage, and passengers were confined to the L.M.S. Seaforth station. From Bridge Street to Seaforth Road, Litherland, shops were flooded to a depth of several feet. Pedestrians were transported across the road on handcarts, and a cyclist attempting to cross was thrown into water up to his waist. And this was two hours after the full force of the storm.

The water had not subsided in the flooded area until far into the night. When it had gone down it was found that it had coated everything below the level it had reached with thick evil-smelling slime. Throughout the night inhabitants in the stricken area were hard at work cleansing their houses and the adjoining streets, and striving to win back order from the chaos created by the storm.

On the evening of June 19th a waterspout was observed in the Liverpool area. The phenomenon was first seen at about 7 p.m. (B.S.T.) moving in a north-westerly direction from the Welsh coast across the estuary of the River Mersey. It was not observed on the Birkenhead side of the river, but in the neighbourhood of Waterloo and Blundellsands it was reported as a remarkable spectacle.

From spectators' reports, the waterspout was in the form of a black column, nearly 300ft. in height, depending from a low bank of dense and threatening cloud. The whole scene appeared ominous and forbidding. The column was described as moving obliquely along the water towards the north-east. Other observers

spoke of the column as being conical in shape and of such a density as to appear almost solid. No shipping was seen in the path of the disturbance, which finally passed over the land a little to the north of Waterloo. Shortly after it was lost to view a violent storm of rain swept the district. The whole occurrence lasted a little over half an hour.

## Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, June 21st, in the Society's Rooms at 49, Cromwell Road, South Kensington, Prof. S. Chapman, F.R.S., President, in the Chair.

The President announced that the Council had decided to recommend to a Special General Meeting of Fellows the adoption of revised by-laws, whereby the annual subscription would become two guineas as from January 1st, 1934, instead of three guineas as at present. The President explained that this action had become possible through the introduction of a number of economies, which it was considered did not impair the efficient working of the Society. It was hoped that as a result there would be an increasing number of new Fellows.

Sir Gilbert Walker, C.S.I., F.R.S., gave an informal talk on "Air Cells" in which he brought forward further evidence relating to the formation of clouds.

*O. F. T. Roberts, M.A.—The functional equation of eddy-diffusion* (Memoir No. 37).

From the hypothesis that the density distribution due to scattering satisfies a functional equation expressing uniformity of scattering power, it is shown that the square of the standard deviation of matter scattered from a plane source varies as the time. The method used to get this is extended so as to obtain the density distribution in a series of hermite polynomials, exhibiting directly the manner in which the distribution may differ from that due to the assumption of eddy scatter analogous to thermal diffusion in a solid. The infinite differential equation corresponding to the functional equation is obtained; and the similar result for homogeneous scattering in three dimensions is derived and extended to scatter from a fixed point or line into a medium with uniform mean flow.

*E. L. Hawke, M.A.—Extreme diurnal ranges of air temperature in the British Isles.*

For reasons well understood, the greatest extremes of heat and cold are normally found at the bottom of valleys. Doubtless owing to the prevalent belief that such situations are damp and unhealthy, too few valley meteorological stations have as yet been established in this country to enable us to set an approximate limit for the range of temperature that may occur in a

single day. A diurnal variation over 40°F. has been registered at Greenwich Observatory only ten times since 1841, and is usually regarded as exceptional anywhere in Britain. Yet records begun four years ago in a Hertfordshire valley characterised by a markedly " continental " climate already include 17 instances of a daily range exceeding 40°F., with 48°F., on March 28th, 1933, as the outstanding example. It is inferred that places so circumstanced are occasionally subjected to fluctuations of temperature amounting to more than 50°F. within a few hours.

# Correspondence

To the Editor, *The Meteorological Magazine.*

## The Colour of Moonlight

In the June issue of *Hemel en Dampkring* I have discussed the question raised in the *Meteorological Magazine*,* why moonlight appears blue in a general way. The following notes, which have been submitted to a specialist on these matters, Dr. Minnaert of Utrecht University, and corrected by him, summarise my conclusions.

According to Dr. Minnaert the phenomenon described by Purkinje (the apparent ascendency in brightness of the blue side of the spectrum over the regions of longer wave-length in mitigated light) has nothing to do with the apparent colour of the illumination of a landscape by the entire band of visible wave-lengths, however weakened that mixture of colours may be. Apart from this the blue colour of a moonlit landscape may be ascribed to five factors, four of which are unimportant from a meteorological point of view :—

1. The scattering of rays in the lowest layer of the atmosphere, containing dust particles, etc., especially during times of well-defined ground inversions, causes a kind of cigarette-smoke veil contributing much to the blue aspect. Dr. Minnaert does not entirely agree with this statement, so I mention it for what it is worth.

2. As soon as artificial sources of light are contrasted with moonlight, there is a tendency on the observer's part to regard the former as white, and the latter as " Air Force blue " in consequence.

3. The colour-distinguishing faculty of the human eye is considerably lessened in circumstances corresponding to the average moonlight intensity. All bright colours are simply struck out of the picture.

4. In regarding a moonlit landscape, the observer's attention is not deflected by landscape details, these being generally invisible in the semi-darkness. Therefore his range of vision

* See *Meteorological Magazine*, 67, 1932, pp. 234. 254, 256, 284 ; 68, 1933, p. 9.

contains about three-quarters of clear sky undoubtedly coloured blue by Rayleigh scattering, and a bluish average is the result.

5. There exists a tendency of the human eye, or perhaps I should say of the human mind, to associate blue with darkness and cold, and on the contrary yellow or red with bright things and warmth.

J. C. M. KRUISINGA.

*Nederlandsche Vereeniging Voor Weenen Sterrenkunde, Vriezenveen, Holland. June 3rd*, 1933.

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## The Temperature of Rain

I was asked recently by Mr. Brunt if I knew of any records of the temperature of rain. I could not remember any, but in thinking about the question it occurred to me that the temperature of rain will normally be just below that of the wet-bulb thermometer, each water drop acting as a wet bulb during its fall. The drops will, however, usually start with a lower temperature than that of the surface air, and if their starting temperature is also below the surface wet-bulb temperature, the difference between the two values will not be quite eliminated by the time the drop has fallen.

Suppose there were no evaporation: then a water drop falling through an atmosphere with a constant lapse-rate would at time $t$ be below the temperature of the air by an amount

$$\alpha\beta v\left(1-e^{-\frac{t}{\alpha}}\right)$$

where $\alpha$ is the lag-coefficient,
$\beta$ is the lapse-rate,
$v$ the rate of fall,
$t$ the time.

This is on the assumption that the drop starts with the temperature of the air at the level of starting. If there were an initial difference of temperature $x$ between the drop and its surrounding air, then the difference at any time would be:—

$$\alpha\beta v\left(1-e^{-\frac{t}{\alpha}}\right)+xe^{-\frac{t}{\alpha}}$$

If we put

$v = 5$ m./sec.
$\beta = \cdot 01$°C. per m.
$\alpha = 0{\cdot}3$
$\alpha\beta v = \cdot 015$°C.

After 100 seconds (or a fall of 500 m.) $e^{-\frac{t}{\alpha}}$ is negligibly small and the constant difference is $\alpha\beta v$ or ·015°C.

The value of $\alpha$ chosen is that given by Linke for a mercury thermometer—a rain-drop should have a coefficient of the same

order of magnitude. If one takes de Quervain's generalized formula, quoted by Linke, and applies it to a water-drop, then for a rain-drop 2 mm. in diameter $a$ is approximately ·32, $v$ being approximately 6 m./sec.

If we take the largest rain-drops of 7 mm. in diameter $a$ comes out as about 2·0, $v$ as 8 m./sec., $\beta$ as ·01, and $a\beta v$ comes to be very nearly 0·16°C.

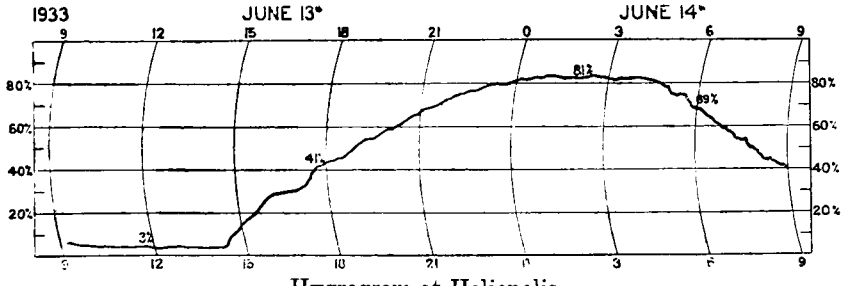
Thus, apart from evaporation, even the largest drops will warm up practically to the air temperature; the net result when evaporation is taken into account will, therefore, be a temperature not very far from the wet-bulb temperature—perhaps a little less than 0·1°C. below it, because in considering the heat balance of the water drop one finds that the effect on evaporation of a rising wet-bulb temperature more than counterbalances the heat required to raise the temperature of the drop.

E. GOLD.

*May 31st*, 1932.

## Behaviour of the Hair Hygrograph at Heliopolis

In the *Meteorological Magazine* for August, 1930, is published a record from the hair hygrograph at the Meteorological Office, Heliopolis, which exhibits remarkably close agreement with the values of relative humidity computed from readings of the wet and dry-bulb thermometers. The attached copy of the hygrogram for June 13-14th, 1933, from the same instrument unchanged in any detail shows that after three years the accuracy of the instrument is unimpaired, the values of relative humidity over a range from 3 per cent to 81 per cent being in excellent agreement with the values computed from the readings of the wet and dry-bulb thermometers. No special care is taken of the instrument beyond the regular washing of the hairs. The muslin on the wet bulb was changed every three or four days and more frequently during dusty conditions.




Hygrogram at Heliopolis.

It may be of interest to note that the low values of relative humidity were recorded during the highest temperature recorded in the Cairo district since 1869 at least. At Heliopolis the maximum temperature on June 13th, 1933, was 118°F. and at Ismailia the maximum was 120°F. The previous long-period

record of 115°F. had been broken only four days before when the maximum at Heliopolis was 116°F. and at Ismailia 118°F.

J. DURWARD.

*Meteorological Office, R.A.F., Heliopolis. June,* 1933.

## Rates of Rainfall

Recently I had occasion to examine the mean hourly rates of rainfall as published for a number of stations each year in *British Rainfall*, and a few points struck me as worth remark. The figures given below are the mean annual rates derived from the data of the seven years 1925-31 :—

*Mean rates of fall.*
(Inches per hour.)

| | | | | | |
|---|---|---|---|---|---|
| Lerwick | ... | ·047 | Croydon | ... | ·052 |
| Renfrew | ... | ·045 | Calshot | ... | ·052 |
| Aberdeen | ... | ·045 | Falmouth | ... | ·055 |
| Leuchars | ... | ·043 | Lympne | ... | ·053 |
| Eskdalemuir | | ·053 | Cork | ... | ·058 |
| Kew ... | ... | ·056 | Valentia | ... | ·065 |

The point of interest here is the relatively high mean rate of fall at the Irish stations, Cork and Valentia, and particularly at the latter. This leads one to inquire as to the behaviour of the mean rate of fall throughout the year. The data for six stations (1925-31) are displayed in graphical form in Fig. 1. In the cases of Lerwick, Aberdeen, Eskdalemuir and Kew the nature of the annual variation is quite definite, a principal

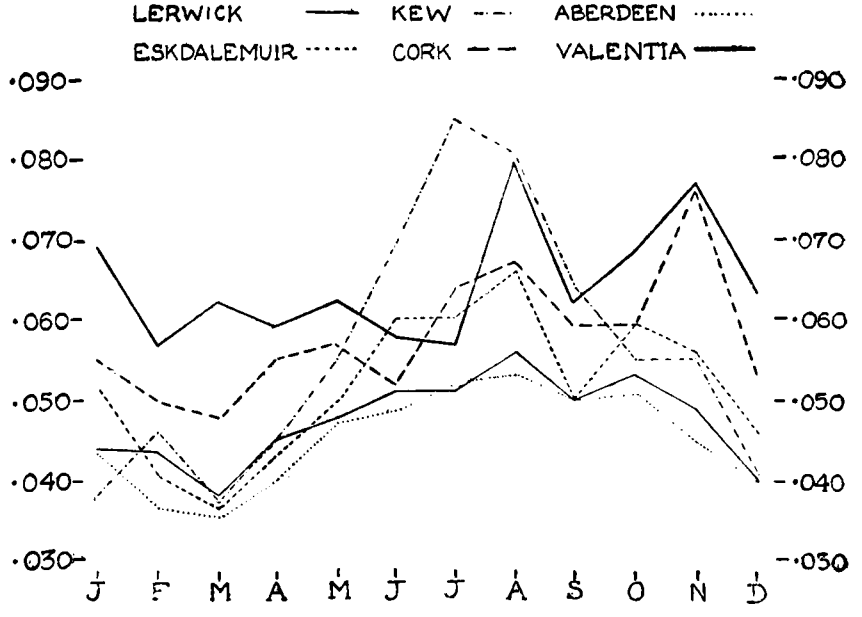



FIG. 1.—Mean rates of rainfall (inches per hour) 1925-31.

minimum in March, a principal maximum in July or August, a secondary minimum in September and a secondary maximum in October or November. When we pass to Cork the same features remain except that the secondary maximum of November has become intensified to be the principal maximum. At Valentia, however, this characteristic annual variation is pretty nearly flattened out, the months February to July and September having nearly the same mean rates, though we are still left with the peaks in August and November. The striking differences therefore as we pass from Scotland or England to the west of Ireland seem to be the vanishing importance of the spring minimum and the increased importance of the November maximum. The comparative uniformity throughout the year in the monthly totals of rainfall in Ireland may perhaps be regarded as supporting the probability of a different sort of annual variation in rate of rainfall.

A. H. R. GOLDIE.

*Edinburgh. June 28th*, 1933.

## Lightning Discharge during Sunshine

You may be interested to hear of a curious occurrence here yesterday at 11h. 50m. during a bright interval, when the sun was shining. I was in my kitchen garden when suddenly a flash of lightning seemed to envelop me and simultaneously there was a terrific crash which for a second almost stunned me.

There had been no rain for several hours before the discharge and it did not begin to rain for three-quarters of an hour after the discharge. There had also been no thunder previously in the immediate neighbourhood, nor was there another clap until three-quarters of an hour later, when it also began to rain. A stone chimney stack on one of my outhouses was struck and fell out. I hear to-day that the glass of a car standing in a garage in the village was splintered at the same time.

N. C. REID.

*Caythorpe Hall, Lincolnshire. June 18th*, 1933.

[This letter was forwarded by Dr. W. A. Harwood, who remarks that the peal of thunder and showers in sight were noted at Cranwell.—ED., *M.M.*]

## Another Thunderstorm Phenomenon

With reference to Mr. Ashmore's letter in the June issue, I have made a regular habit of listening in to thunderstorms since 1918. I find that the " lightning " is invariably audible before the flash, in fact it seems to be the case that the discharge tries out various paths before it finally produces the flash.

A. G. W. HOWARD.

*June 21st*, 1933.

## The Thunderstorm of May 6th, 1933

In the article under this heading published in the June issue of this magazine I notice that after my report on the line squall is the remark " the times referred to in this letter are presumably B.S.T." I would respectfully point out that the times referred to are G.M.T.

I regret that I have not access to a map showing the isochrones of the movement of this occlusion, but it is apparent from Mr. Farquharson's article that the occlusion was moving in a north-easterly direction in a line from north-west to south-east across London. Since Waltham Cross is 12 miles north from London and almost on the meridian of Greenwich, it follows that the occlusion must have reached London first.

This is in agreement with the times in my report. The occlusion passed over London at about 16h. 50m. and reached Waltham Cross 30 minutes later at 17h. 20m.

DONALD L. CHAMPION.

187, *High Street, Waltham Cross, Herts. July 4th*, 1933.

As I indicated in the article under this heading the occlusion was becoming very diffuse by the time it reached London. For this reason it was very difficult to time its arrival at Waltham Cross and I took the observations of Mr. Champion as indicating that arrival. The difference of time would not affect my suggestion that the phenomena described were those associated with the occlusion. J. S. FARQUHARSON.

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## Solar Halo, July 1st, 1933

An unusual solar phenomenon occurred on Saturday, July 1st, when a brilliantly coloured halo of 46° was first noticed at 18h. G.M.T. and remained exceptionally bright until 18h. 25m. when fading commenced; by 18h. 40m. it had practically disappeared. The colouring of the halo was green on the inner edge nearest the sun and blue on the outer edge.

There was no sign of any red on the inside of the halo which is usual in this phenomenon, nor was there any trace of the 22° halo.

At the time visibility was moderately good, there being a surface wind ESE., force 1. Haze was apparent towards the west. The phenomenon was observed in clouds of cirrus and cirro-stratus, and the sun was covered during the latter part of the time by alto-stratus which moved slowly from a north-westerly point, even then the colours in the arc were brilliant.

Over the remainder of the sky there were very fine wisps of cirro-stratus cloud, and towards the north some mare's tails.

E. J. HORREX.

"*Colombo*," 32, *Ceylon Road, Westcliff-on-Sea. July 4th*, 1933.

## Vertical Currents Associated with Mammato Clouds

A balloon ascent at Agra at 16h. 35m. I.S.T. on February 19th, 1932, primarily made for the purpose of determining the height of an alto-stratus cloud, throws some light on the physical processes taking place in mammato-cumulus clouds. The purpose of this letter is to give a summary of these observations.

At 8h. on February 19th a " low " associated with a western disturbance which was passing eastwards through Kashmir, was centred over west Central India. A few thunder-showers occurred during the day at Jhansi, Cawnpore, Benares, Allahabad, &c. At Agra there was the usual sequence of clouds associated with the passage of an extra-tropical disturbance and a light shower at 16h. Following this shower, the alto-stratus cloud in south-west and not far from the zenith, developed a festooned structure with a tendency to spread northward. Three minutes before entering the cloud which by then had developed a clear mammato structure, the vertical angle of the balloon was found to increase so rapidly that the tangent screw controlling this movement had to be unclamped and the theodolite manipulated by hand. After a few seconds the balloon became stationary and then moved horizontally for about ten or fifteen seconds. Thereafter the vertical angle was found to decrease rapidly. This series of changes was found to be repeated three times before the balloon actually entered the mammato cloud and vanished out of sight.

Although changes in the vertical and horizontal angles are usually interpreted as being due to changes of wind velocity with height, it is difficult to explain such large velocities in opposite directions in two or three heights within a short range, and therefore one feels justified in attributing it to vertical movements in the air. The observation therefore indicates the presence of upward, downward and possibly also horizontal currents of air near the bottom of a mammato-cumulus cloud layer.

Another balloon was sent up immediately after the disappearance of the first balloon. The festooned and the mammato structure of the cloud had by then disappeared and the balloon did not show the phenomena observed during the previous ascent, thus showing that the upward and downward motions experienced by the first ballon were mainly due to the presence of the mammato cloud. The alto-stratus cloud was 3,414 metres above ground as shown by the first ascent and 3,100 metres as shown by the second ascent, indicating a lowering of the base of the cloud. By 17h. 30m. I.S.T. the clouds cleared away. It may be mentioned here that mammato clouds are often observed at Agra during the pasage of western disturbances and they have been found short-lived.

It has been observed that if instability is produced as a result of density distribution in a thin layer of fluid, the latter breaks up into polygonal cells, there being upward motion at the centre of each cell and descending motion at the common boundary of the various neighbouring cells. According to Dr. Simpson,* after the passage of a thunderstorm there exist in the atmosphere conditions which are markedly favourable for the setting up of such an instability, and if the formation of mammato clouds is due to the same type of instability, one should naturally expect ascending and descending currents in them. The present observations clearly support the above view of the structure and formation of mammato clouds. KRISHNA CHANDRA.

*Upper Air Observatory, Agra, India. January 23rd,* 1933.

## Atmospheric Circulation over Tropical Africa

The advent of air services to Africa has given meteorology a fresh impetus, and the *Geophysical Memoir* dealing with the atmospheric circulation over tropical Africa has appeared at an opportune moment. It is bound to be appreciated by those who are interested in African meteorology, as it provides a basis for the study both of the general problem and of the climates of smaller areas.

Scarcity of reliable information, and lack of accurate altitudes, must have rendered the work extremely difficult, and, knowing this, one is loath to criticise. The following points may, however, be of interest.

The altitudes of stations in Southern Rhodesia are now satisfactorily determined, the pressure normals checked, and the old barometers have been standardised against new instruments, and we are in a position to say that the pressures shown in the memoir for this area are some three millibars low.

With regard to the map showing air movements for January, the following suggestions are offered :—

There seems to be no evidence and no justification for bringing the Egyptian air stream 3,500 miles down the axis of Africa. Apart from the time which such a stream would take to accomplish the journey over a region where the winds are mostly light, one would expect the stream of air to be dry. The northerly winds, however, bring abundant moisture to north-west Rhodesia and Bechuanaland, and a dry northerly wind is unknown in Southern Rhodesia once the rainy season has commenced.

It seems more reasonable to make the southernmost limit of the Egyptian steam coincide with the kink in the four-inch isohyet, about latitude 3°S., longitude 29°E. It is more probable that the part of the south-west monsoon crossing the west coast between the equator and latitude 10°S., turns south-eastward

* G. C. Simpson, *Nature*, Vol. 113, 1924, p. 82.

and spreads over the Belgian Congo and north-west Rhodesia, while the part crossing between 10° and 15°S. latitude enters the Kalahari desert, and, being drier, gives less rain. This current also enters Southern Rhodesia when pressure is low.

The SE. trade of the Indian Ocean which enters South Africa in the east, turns southward on the western side of the Drakensberg Mountains, and mixing with air from the north-east monsoon and the eastern edge of the Kalahari current passes through the Orange Free State to the north of Cape Province. The area traversed by this mixed current is noted for violent thunderstorms. The SE. trade is often entirely displaced by the passage of a low up the south-east coast. At other times it is strengthened by a high pressure on the south-east coast, and at such times it may cover the whole of Southern Rhodesia.

In Southern Rhodesia a steady E. wind is associated with fair weather, a steady NE. wind with thunder-showers and NW. winds with rain periods. Sometimes the NW. current appears above a NE. wind. This gives rain and a marked amount of frontal activity. Fronts also occur when a NE. or NW. current is displaced by the SE. trade. Rhodesia is frequently the battleground of these currents, and a knowledge of their origin and life-history is, therefore, important to meteorologists in these parts.

J. S. PEAKE.

*Meteorological Office, Salisbury, Southern Rhodesia. April 10th*, 1933.

We welcome Mr. Peake's letter. As he says, the work of preparing the memoir in question was exceedingly difficult, and many questions remain which can only be settled by more exact local knowledge than was available to us in London. In fact, the memoir originated in an attempt to clear up a jungle of conflicting data about central Africa.

The addition of about 3 mb. to the mean pressures over Southern Rhodesia, however, introduces a number of new difficulties. For example, it involves us in the alternative that either the pressure (or height) of Pretoria and Johannesburg must be incorrect or that a wedge of high pressure points north-eastward into the interior of Africa across Southern Rhodesia. It would also give a rather steep pressure gradient between Salisbury (Rhodesia) and Zomba (Nyasaland), the height of which has also recently been re-determined by survey. Further material from this part of Africa will be very useful.

The corresponding change in the pressure map for January would in fact not make much difference in the source of the air reaching the greater part of Southern Rhodesia in that month, which is shown in our maps as the southern Indian Ocean. The Egyptian stream is drawn further east, but the fact that it crosses the rainy region of the upper Congo is admittedly a

difficulty, and the source of this rainfall would be more obvious if the air over the whole of this moist region could be derived from the equatorial Indian Ocean.

We naturally did not suppose that the " fronts " shown in the memoir were immovable. Successive years, and even a single season, can be expected to show wide swings. We attempted to show only the simplest outlines, while the details must be filled in by the meteorologists on the spot. From Mr. Peake's last two paragraphs there appears to be as much scope for the definition of air masses of different origin in central Africa as there was in Europe.

C. E. P. BROOKS.
S. T. A. MIRRLEES.

## NOTES AND QUERIES

### High Pilot-Balloon Ascents at Shoeburyness

On Thursday, June 15th, 1933, a very high double-theodolite pilot-balloon ascent was made at Shoeburyness. This ascent was commenced at 08.10 and a height of 57,000 feet was secured in 53 minutes. The balloon then burst, a very unfortunate occurrence, as it was still rising strongly and the visibility was remarkably good. This ascent is a two-theodolite record for the station, easily surpassing the previous record of 52,000 feet set up on June 4th, 1925.

The balloon used was a 750-gram one by Pirelli. It was given a free lift of 910 grams and was unloaded. Its mean rate of ascent over the first 10 minutes was 1,260 feet per minute. The results of the ascent indicated a light wind from a north or north-easterly point up to the maximum height attained.

At 18.15 on the same day a further ascent was made with a similar balloon. A free lift of 680 grams was given and the mean rate of ascent secured was 830 feet per minute during the first ten minutes of flight. The balloon attained a height of 42,000 feet in 55 minutes. It burst at this point, unfortunately. Visibility was good and the balloon could have been held in both theodolites for a considerable time longer. A fairly steady current throughout from a north-westerly point was found.

C. E. BRITTON.

### The Secular Variation of Temperature at Spitsbergen

The deviations of temperature from normal at Green Harbour, Spitsbergen, quoted in the monthly article on " Weather of the Month," have in the last few years shown some astounding positive values which seemed to require investigation. The data available consist of monthly means at 8h. local time for the period December, 1911, to August, 1930, extracted from the year books of the Norwegian Meteorological Institute, and for

the remainder of the period to February, 1933, corresponding values computed from the daily figures in the British *Daily Weather Report*.

The annual means (Table 1) show apparently an eleven-year cycle superposed on a steady rise.

*Table I.—Mean Annual Temperature at Spitsbergen, 8h. °F.*

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1910 | — | — | 13·8 | 18·7 | 16·2 | 14·7 | 13·6 | 9·1 | 18·3 | 16·7 |
| 1920 | 22·3 | 18·2 | 22·5 | 23·5 | 22·6 | 21·6 | 19·4 | 18·3 | 19·2 | 16·9 |
| 1930 | 22·8 | 25·1 | 22·3 | | | | | | | |

Taking the three variables :—

T = mean annual temperature (°F.)

t = time in years from 1911

s = square root of sunspot number*

we find the partial correlation coefficient between temperature and time to be +·79, and that between temperature and square root of sunspot number −·66. The regression equation is

$$T = 18{\cdot}1°F. + 0{\cdot}49t - 0{\cdot}75s.$$

The sunspot minima of 1913 and 1923 both coincide with maxima in the curve of mean annual temperatures; the pronounced sunspot maximum of 1917 corresponds with a pronounced minimum of temperature, but the temperature minimum of 1929 comes one year later than the corresponding sunspot maximum which, however, was not well marked.

The most remarkable features of the period are the extraordinarily low temperatures during the winter of 1916-7, the mean for November to April being −11·4°F. and the mean for February −21·0°F., and the mildness of the winter of 1930-1, the mean for November to April being +16·5°F. and that for December, 1930, +23·1°F.

It is well known that there is a positive relation between the amount of ice in Arctic waters and the number of sunspots, and the temperature variations at Spitsbergen appear to show another aspect of this relationship. The secular rise may be related to the remarkable secular rise of winter temperatures in western Europe, to which attention has repeatedly been drawn in recent years.

C. E. P. Brooks.

## Meteorology in the Smithsonian Report

On December 18th, 1931, the United States "Research Corporation" presented grants and commemorative medals to Dr. A. E. Douglass for his work on tree-growth and rainfall, and to Dr. E. Antevs for his work on the chronology of the late Ice Age in America. An account of the ceremony of presentation is given in the Smithsonian Report for 1931, including interesting summaries of the present state of their researches by

*See *London, Q.J.R. Meteor. Soc.* 53, 1927, *p.* 68.

Douglass and Antevs. Other papers in the same volume describe the results of " Twenty-five years' study of solar radiation," by Dr. C. G. Abbot, and " Sun spots and radio reception," by H. T. Stetson.

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## Reviews

*Grundbegriffe der Wetteranalyse.* By Gustav Swoboda. Sammlung Gemeinnütziger Vorträge No. 641/644. Prague, 1932.

This little book gives in very readable form and with a wealth of illustration an account of the origin of the polar front theory of cyclones and of the most recent developments of that theory. Commencing with a general account of cyclones and anticyclones, Dr. Swoboda goes on to describe the life history of an ideal cyclone, cyclone families and the structure of anticyclones, the descriptions being three-dimensional and carried up into the stratosphere. Thus, for example, the slowing up of an occluded cyclone is explained as due to the extension of cyclonic motion to the cirrus level. The third section defines polar and tropical air and their characteristics, and the fourth describes how the interaction of these air masses brings about the phenomena of cyclone families, regeneration and fronts; there is also an important sub-section on the importance of humidity. The last section shows how the polar front theory throws new light on the general circulation of the atmosphere and its seasonal and periodic changes, the work of Bergeron on " dynamic climatology " being fully described. Then comes a two-page table giving in detail the characteristics of masses of different origin. There are no fewer than 27 illustrations, each with a full explanation.

*L'Influence Solaire et les Progrès de la Météorologie.* Henri Mémery. Observatoire de Talence. 1932.

M. Mémery continues his investigations into what may be termed the small-scale relations between solar and terrestrial phenomena, tracing the effect of individual sunspots on the weather of individual days. In this paper he adopts a new method; daily averages of the average sunspot numbers over a series of years give a markedly irregular curve of annual variation, and the irregularities are compared with those of the annual variation of temperature, rainfall and earthquakes. The curves are at first glance striking, but the fit of the details is not always as good as might be desired, and it is not unlikely that a careful statistical discussion might show that the apparent agreements may be merely coincidences. The reviewer also finds difficulty in accepting the idea of the regular annual recurrence of fluctuations of solar activity.

## Books Received

*Report on rainfall registration in Mysore for* 1930 *and for* 1931. By C. Seshachar, Bangalore, 1931 and 1932.

*Meteorology in Mysore for* 1930 *and* 1931, being the results of observations at Bangalore, Mysore, Hassan, Chitaldrug, Balehonnur and Jogimatti. Thirty-eighth and thirty-ninth Annual Reports, Bangalore, 1931 and 1932.

## News in Brief

Col. Sir Henry Lyons, F.R.S., Director of the Science Museum, has been elected President of the Institute of Physics for the session 1933-4.

Prof. Vilhelm F. K. Bjerknes of the Physical Institute of the University of Oslo was elected a foreign member of the Royal Society at the meeting held on May 25th, 1933.

Sir Richard Gregory, Editor of *Nature* and President of the Royal Meteorological Society, 1928-30, has been elected a Fellow of the Royal Society.

The Howard Prize of the Royal Meteorological Society has been awarded to Cadet J. S. Robertson of H.M.S. Training Ship *Conway* for the best essay on "Visibility and fog."

At a meeting of the Society on July 3rd Sir Napier Shaw was elected an Honorary Fellow of the Royal Society of Edinburgh.

It has been announced that Brigadier E. E. B. Mackintosh, D.S.O., will succeed Col. Sir Henry Lyons, F.R.S., as Director of the Science Museum.

## The Weather of June, 1933

Pressure was below normal over the United States and Canada (except for a region round the Hudson Bay), the south-western part of the North Atlantic, northern Africa including Madeira, and Europe except northern Scandinavia and Russia. The greatest deficits were 5·1mb. at Paris and Helder, 5·3mb. at Zurich and 5·8mb. at Lemberg. Pressure was above normal over Mexico, the Hudson Bay, the central part of the North Atlantic and northern Scandinavia and Russia, the greatest excess being 5·3mb. in the Atlantic at 50°N., 30°W Temperature was above normal in London, Scandinavia and Spitsbergen, and below normal in central Europe and at Lisbon. Rainfall was below normal in London and parts of Scandinavia and above normal in central Europe, eastern Gothaland and Spitsbergen.

June opened with fine, warm weather in the east of England under the influence of an anticyclone over the Continent, but in the west and south-west weather was unsettled. By the 4th the fine weather had spread over the country and high maximum temperatures were recorded; in many parts of England temperatures of 85°F. and over were reached. Some stations on the east and south coasts, however, did not record these high temperatures, the highest temperature reached at Gorleston during this period was 67°F. In Ireland, also, the high temperatures were not reached. Much sunshine was registered during this period; Croydon had 112·2hrs. from the 1st to the 8th, an average of 14 hours a day; Cambridge had 73·2hrs. in five days and Norwich had 74·9hrs. from the 4th to the 8th, an average of 15 hours a day. By the 9th an anticyclone on the Atlantic extended over the British Isles and gave a current from a northerly direction and temperatures fell generally. Weather was cool until the 13th; on that day rain fell in the east, ending a drought which had lasted in parts of south-east England for 16 days. The 14th and 15th were warm in the south and Midlands. On the 15th a depression moving southwards from Iceland caused rain and a gale in Scotland on the 16th and strong squally winds and cool unsettled weather on the 17th and 18th. Pressure remained low over the British Isles until the 25th; thunderstorms occurred accompanied by heavy rain and sometimes by hail. Whaley Bridge, Cheshire, had 1·85in. on the 18th and Crickhowell, Dan-y-Park, Brecon, 1·56in. on the 24th.

The abnormal frequency of thunderstorms during June is described on pp. 129-31.

The distribution of bright sunshine for the month was as follows:—

| | Total (hrs.) | Diff. from normal (hrs.) | | Total (hrs.) | Diff. from normal (hrs.) |
|---|---|---|---|---|---|
| Stornoway | 202 | +24 | Liverpool | 206 | + 6 |
| Aberdeen | 236 | +52 | Ross-on-Wye | 197 | 0 |
| Dublin | 137 | —52 | Falmouth | 238 | +17 |
| Birr Castle | 139 | —25 | Gorleston | 239 | +29 |
| Valentia | 139 | —49 | Kew | 259 | +62 |

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The special message from Brazil states that rain was scarce in the north, centre and south, the averages being 1·21in. 0·47in. and 1·85in. below normal. Four anticyclones and some active depressions passed across the country. During the last 10 days frost was general in the south. The crops were doing well in the north; but in the centre and south they were affected by the frost and low temperature, especially the tobacco, coffee, cotton and beans. At Rio de Janeiro pressure was 0·7mb. above normal and temperature 19·8°F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.*

On the 2nd exceptionally heavy rain, which afterwards turned to sleet and hail, was reported from Rome; the storm lasted some hours, and when it was over an inch of ice lay on the streets. Serious damage due to heavy storms on the 15th-16th was reported from the area round San Sebastian, houses were flooded, two people were drowned and three others were buried in a landslide. Severe storms also occurred over a large part of France on the 16th-18th, causing damage to crops. Snow fell on the mountains in northern Italy about the middle of the month; heavy rains caused rivers to overflow, the waters in Lake Maggiore rose 6 feet in 48 hours. During a violent storm a waterspout which formed over Lake Varese burst on the shore and let fall a rain of fish. (*Morning Post*, June 3rd; *The Times*, June 19th and 24th.)

The monsoon rains were particularly heavy in Lower Burma at the beginning of the month, and there were extensive floods in the Pegu district. Heavy rain caused damage in Anatolia, floods wrecking a train. Exceptionally high temperatures were reached in Cairo during the first half of June, the record being beaten twice, 116°F. (46·9°C. at Giza) was reached on the 9th and 118°F. (48°C. at Helwan) on the 13th.* (*The Times*, June 5th and 19th and *Cairo Physical Department, Daily Weather Report*, June 10th and 14th.)

A hurricane accompanied by violent rainstorms struck Trinidad on the night of the 27th, eight lives were lost and hundreds of houses were damaged or destroyed; serious damage was done to the coconut and cocoa plantations. (*The Times*, June 30th and July 5th.) Hurricanes are very rare so far south as Trinidad.

A heat wave lasting about ten days occurred in a large part of the United States during the first part of the month. Many stations recorded 100°F. including Albany, N.Y., and Washington, D.C. High temperatures were also reached in Ontario and Quebec. During the first part of the month weather was generally favourable in Canada for the crops, but in the middle of the month the prairies experienced great heat, which lasted some days, and by the end of the month the crops were suffering from lack of moisture. (*The Times*, June 10th-26th, and *Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin.*)

## General Rainfall for June, 1933

| | | |
|---|---|---|
| England and Wales ... | 92 | per cent of the average 1881-1915. |
| Scotland ... ... ... | 85 | |
| Ireland ... ... ... | 94 | |
| British Isles ... ... | 91 | |

*See also p. 137.

## Rainfall: June, 1933: England and Wales.

| Co. | Station | In. | Per-cent. of Av. | Co. | Station | In. | Per-cent. of Av. |
|---|---|---|---|---|---|---|---|
| *Lond.* | Camden Square ..... | 1·85 | 92 | *Leics.* | Thornton Reservoir ... | 2.38 | 110 |
| *Kent.* | Tenterden, Ashenden... | 1·28 | 67 | ,, . | Belvoir Castle..... | 2·24 | 117 |
| ,, . | Folkestone, Boro. San. | 2·43 | ... | *Rut.* | Ridlington ..... | 2·70 | 141 |
| ,, . | St. Peter's, Hildersham | ... | ... | *Lincs.* | Boston, Skirbeck ..... | 2·14 | 118 |
| ,, . | Eden'bdg., Falconhurst | 1·63 | 74 | ,, | Cranwell Aerodrome ... | 2·05 | 122 |
| ,, . | Sevenoaks, Speldhurst | 1·56 | ... | ,, . | Skegness, Marine Gdns | 1·77 | 98 |
| *Sus.* | Compton, Compton Ho. | 2·09 | 84 | ,, . | Louth, Westgate ..... | 1·87 | 87 |
| ,, . | Patching Farm ..... | 3·41 | 169 | ,, . | Brigg, Wrawby St. ... | 1·85 | ... |
| ,, . | Eastbourne, Wil. Sq. | 2·33 | 126 | *Notts.* | Worksop, Hodsock ... | 2·13 | 108 |
| ,, . | Heathfield, Barklye ... | 2·03 | 97 | *Derby.* | Derby, L. M. & S. Rly. | 1·48 | 66 |
| *Hants.* | Ventnor, Roy. Nat. Hos. | 1·04 | .57 | ,, . | Buxton, Terr. Slopes | 4·63 | 144 |
| ,, . | Fordingbridge, Oaklnds | 1·81 | 98 | *Ches.* | Runcorn, Weston Pt... | 1·56 | 60 |
| ,, . | Ovington Rectory ..... | 5·03 | 217 | *Lancs.* | Manchester, Whit Pk. | 3·69 | 140 |
| ,, . | Sherborne St. John ... | 2·66 | 125 | ,, . | Stonyhurst College ... | 2·53 | 82 |
| *Herts.* | Welwyn Garden City... | 1·83 | ... | ,, . | Southport, Hesketh Pk | 1·42 | 65 |
| *Bucks.* | Slough, Upton ..... | 1·47 | 71 | ,, . | Lancaster, Greg Obsy. | 1·67 | 65 |
| ,, . | H. Wycombe, Flackwell | 2·96 | ... | *Yorks.* | Wath-upon-Dearne ... | ·90 | 41 |
| *Oxf.* | Oxford, Mag. College... | 1·22 | 57 | ,, . | Wakefield, Clarence Pk. | ·99 | 46 |
| *Nor.* | Pitsford, Sedgebrook... | 2·14 | 111 | ,, . | Oughtershaw Hall..... | 3·09 | ... |
| ,, . | Oundle..... | 3·10 | ... | ,, . | Wetherby, Ribston H. | 1·34 | 64 |
| *Beds.* | Woburn, Crawley Mill | 1·89 | 96 | ,, . | Hull, Pearson Park ... | 1·59 | 77 |
| *Cam.* | Cambridge, Bot. Gdns. | 4·86 | 230 | ,, . | Holme-on-Spalding ... | 2·66 | ... |
| *Essex.* | Chelmsford, County Lab | 1·09 | 57 | ,, . | West Witton, Ivy Ho. | 2·24 | 110 |
| ,, . | Lexden Hill House ... | 1·83 | ... | ,, . | Felixkirk, Mt. St. John | 1·68 | 77 |
| *Suff.* | Haughley House..... | 1·89 | ... | ,, . | York, Museum Gdns. | 1·59 | 75 |
| ,, . | Campsea Ashe..... | 1·57 | 83 | ,, . | Pickering, Hungate ... | 1·96 | 92 |
| ,, . | Lowestoft Sec. School | 2·44 | 135 | ,, . | Scarborough ..... | 1·22 | 66 |
| ,, . | Bury St. Ed, Westley H. | 2·02 | 96 | ,, . | Middlesbrough ..... | 1·62 | 86 |
| *Norf.* | Wells, Holkham Hall | 1·34 | 68 | ,, . | Balderdale, Hury Res. | 1·96 | 83 |
| *Wilts.* | Devizes, Highclere..... | 1·43 | 63 | *Durh.* | Ushaw College ..... | 1·54 | 71 |
| ,, . | Calne, Castleway ..... | 2·52 | 109 | *Nor.* | Newcastle, Town Moor | 2·16 | 99 |
| *Dor.* | Evershot, Melbury Ho. | 1·53 | 67 | ,, . | Bellingham, Highgreen | 1·94 | 84 |
| ,, . | Weymouth, Westham. | ·37 | 21 | ,, . | Lilburn Tower Gdns... | 1·73 | 84 |
| ,, . | Shaftesbury, Abbey Ho. | 2·21 | 95 | *Cumb.* | Carlisle, Scaleby Hall | 2·04 | 81 |
| *Devon.* | Plymouth, The Hoe ... | 2·72 | 98 | ,, . | Borrowdale, Seathwaite | 4·00 | 66 |
| ,, . | Holne, Church Pk. Cott. | 2·56 | 89 | ,, . | Borrowdale, Moraine... | 4·54 | ... |
| ,, . | Teignmouth, Den Gdns. | 2·24 | 114 | ,, . | Keswick, High Hill... | 2·71 | 93 |
| ,, . | Cullompton..... | 1·93 | 91 | *West.* | Appleby, Castle Bank | 1·95 | 85 |
| ,, . | Sidmouth, Sidmount... | 3·11 | 148 | *Mon.* | Abergavenny, Larch... | 2·94 | 121 |
| ,, . | Barnstaple, N. Dev. Ath | 1·38 | 62 | *Glam.* | Ystalyfera, Wern Ho. | 2·68 | 71 |
| ,, . | Dartm'r, Cranmere Pool | 2·90 | ... | ,, . | Cardiff, Ely P. Stn. ... | 1·47 | 59 |
| ,, . | Okehampton, Uplands | 1·81 | 65 | ,, . | Treherbert, Tynywaun | 3·46 | ... |
| *Corn.* | Redruth, Trewirgie ... | 2·04 | 82 | *Carm.* | Carmarthen Friary ... | 1·93 | 67 |
| ,, . | Penzance, Morrab Gdn. | 1·94 | 87 | *Pemb.* | Haverfordwest, School | 2·68 | 99 |
| ,, . | St. Austell, Trevarna... | 3·07 | 118 | *Card.* | Aberystwyth ..... | 2·80 | ... |
| *Soms.* | Chewton Mendip ..... | 1·61 | 54 | *Rad.* | Birm W. W. Tyrmynydd | 4·56 | 139 |
| ,, . | Long Ashton ..... | 1·19 | 47 | *Mont.* | Lake Vyrnwy..... | 3·50 | 111 |
| ,, . | Street, Millfield..... | 1·33 | 62 | *Flint.* | Sealand Aerodrome ... | 1·32 | 62 |
| *Glos.* | Blockley ..... | 1·52 | ... | *Mer.* | Dolgelley, Bontddu ... | 5·52 | 158 |
| ,, . | Cirencester, Gwynfa ... | 1·33 | 55 | *Carn.* | Llandudno ..... | 1·59 | 76 |
| *Here.* | Ross, Birchlea..... | 2·15 | 99 | ,, . | Snowdon, L. Llydaw 9 | 9·85 | ... |
| *Salop.* | Church Stretton..... | 3·26 | 135 | *Ang.* | Holyhead, Salt Island | 1·39 | 65 |
| ,, . | Shifnal, Hatton Grange | 2·83 | 127 | ,, . | Lligwy..... | 1·68 | ... |
| *Staffs.* | Market Drayt'n, Old Sp. | 1·74 | 72 | *Isle of Man* | | | |
| *Worc.* | Ombersley, Holt Lock | 1·43 | 63 | | Douglas, Boro' Cem. ... | 2·70 | 109 |
| *War.* | Alcester, Ragley Hall.. | 1·91 | 84 | *Guernsey* | | | |
| ,, . | Birminghm, Edgbaston | 2·26 | 97 | | St. Peter P't. Grange Rd | 1·64 | 89 |

## Rainfall: June, 1933: Scotland and Ireland.

| Co. | Station | In. | Per-cent. of Av. | Co. | Station | In. | Per-cent of Av. |
|---|---|---|---|---|---|---|---|
| *Wig* . | Pt. William, Monreith | 2·50 | 106 | *Suth* . | Melvich ..... | 1·70 | 88 |
| ,, . | New Luce School..... | 3·22 | 111 | ,, . | Loch More, Achfary... | 3·99 | 108 |
| *Kirk* . | Dalry, Glendarroch ... | 2·61 | 94 | *Caith* . | Wick ..... | 1·46 | 81 |
| ,, . | Carsphairn, Shiel ..... | 4·11 | 103 | *Ork* . | Deerness ..... | 1·04 | 57 |
| *Dumf* . | Dumfries, Crichton, R.I | 2·45 | 103 | *Shet* . | Lerwick ..... | ·94 | 53 |
| ,, . | Eskdalemuir Obs..... | 2·20 | 70 | *Cork* . | Caheragh Rectory ..... | 1·08 | ... |
| *Roxb* . | Branxholm ..... | 1·29 | 57 | ,, . | Dunmanway Rectory . | 1·23 | 35 |
| *Selk* . | Ettrick Manse..... | ·87 | 24 | ,, . | Cork, University Coll. | 1·59 | 63 |
| *Peeb* . | West Linton ..... | 2·12 | ... | ,, . | Ballinacurra ..... | 1·75 | 67 |
| *Berw* . | Marchmont House..... | 1·09 | 47 | *Kerry* . | Valentia Obsy..... | 2·86 | 89 |
| *E. Lot* . | North Berwick Res.... | 1·54 | 93 | ,, . | Gearahameen ..... | 3·40 | 68 |
| *Midl* . | Edinburgh, Roy. Obs. | 1·88 | 94 | ,, . | Killarney Asylum ..... | ... | ... |
| *Lan* . | Auchtyfardle ..... | 1·81 | ... | ,, . | Darrynane Abbey ..... | 1·93 | 61 |
| *Ayr* . | Kilmarnock, Kay Pk. . | 2·35 | ... | *Wat* . | Waterford, Gortmore... | 2·26 | 86 |
| ,, . | Girvan, Pinmore..... | 2·95 | 102 | *Tip* . | Nenagh, Cas. Lough .. | 2·66 | 108 |
| *Renf* . | Glasgow, Queen's Pk. . | 1·98 | 86 | ,, . | Roscrea, Timoney Park | 3·72 | ... |
| ,, . | Greenock, Prospect H. | 3·09 | 94 | ,, . | Cashel, Ballinamona ... | 2·19 | 95 |
| *Bute* . | Rothesay, Ardencraig. | 3·05 | ... | *Lim* . | Foynes, Coolnanes..... | 1·72 | 67 |
| ,, . | Dougarie Lodge..... | 2·62 | ... | ,, . | Castleconnel Rec..... | 2·13 | ... |
| *Arg* . | Ardgour House ..... | 5·80 | ... | *Clare* . | Inagh, Mount Callan... | 2·96 | ... |
| ,, . | Glen Etive ..... | 3·88 | 83 | ,, . | Broadford, Hurdlest'n. | 2·30 | ... |
| ,, . | Oban ..... | 3·60 | 121 | *Wexf* . | Gorey, Courtown Ho... | 2·93 | 121 |
| ,, . | Poltalloch ..... | 4·06 | 136 | *Kilk* . | Kilkenny Castle..... | 2·13 | 88 |
| ,, . | Inveraray Castle ..... | 5·28 | 133 | *Wick* . | Rathnew, Clonmannon | 1·67 | ... |
| ,, . | Islay, Eallabus ..... | 1·84 | 70 | *Carl* . | Hacketstown Rectory.. | ... | ... |
| ,, . | Mull, Benmore ..... | 2·90 | ... | *Leix* . | Blandsfort House ..... | 2·93 | 113 |
| ,, . | Tiree ..... | 2·11 | 83 | ,, . | Mountmellick..... | 2·61 | ... |
| *Kinr* . | Loch Leven Sluice..... | 1·84 | 84 | *Offaly* . | Birr Castle ..... | 2·51 | 109 |
| *Perth* . | Loch Dhu ..... | 3·00 | 72 | *Kild'r.* | Monasterevin ..... | ... | ... |
| ,, . | Balquhidder, Stronvar | 2·40 | ... | *Dublin* | Dublin, FitzWm. Sq.... | 1·25 | 64 |
| ,, | Crieff, Strathearn Hyd. | 1·52 | 58 | ,, . | Balbriggan, Ardgillan. | 1·58 | 79 |
| ,, . | Blair Castle Gardens... | ·73 | 37 | *Meath.* | Beauparc, St. Cloud ... | 2·56 | ... |
| *Angus.* | Kettins School ..... | 1·34 | 64 | ,, . | Kells, Headfort..... | 2·97 | 112 |
| ,, . | Pearsie House..... | 1·65 | ... | *W.M* . | Moate, Coolatore ..... | 2·89 | ... |
| ,, . | Montrose, Sunnyside... | ... | ... | ,, . | Mullingar, Belvedere... | 2·77 | 106 |
| *Aber* . | Braemar, Bank ..... | 1·54 | 79 | *Long* . | Castle Forbes Gdns.... | 3·11 | 121 |
| ,, . | Logie Coldstone Sch.... | 1·28 | 66 | *Gal* . | Ballynahinch Castle... | 3·78 | 107 |
| ,, . | Aberdeen, King's Coll. | ·86 | 50 | ,, . | Galway, Grammar Sch. | 1·50 | ... |
| ,, . | Fyvie Castle ..... | 1·40 | 67 | *Mayo* . | Mallaranny..... | 4·36 | ... |
| *Moray* | Gordon Castle..... | 1·80 | 88 | ,, . | Westport House..... | 2·98 | 110 |
| ,, . | Grantown-on-Spey..... | 1·55 | 69 | ,, . | Delphi Lodge..... | 6·69 | 116 |
| *Nairn.* | Nairn ..... | 1·83 | 104 | *Sligo* . | Markree Obsy..... | 4·05 | 138 |
| *Inv's* . | Ben Alder Lodge..... | 2·31 | ... | *Cavan.* | Belturbet, Cloverhill... | 2·41 | 99 |
| ,, . | Kingussie, The Birches | ·98 | ... | *Ferm* . | Enniskillen, Portora... | 2·52 | ... |
| ,, . | Loch Quoich, Loan..... | 4·75 | ... | *Arm* . | Armagh Obsy..... | 2·14 | 85 |
| ,, . | Glenquoich ..... | 3·28 | 67 | *Down* . | Fofanny Reservoir..... | 3·72 | ... |
| ,, . | Inverness, Culduthel R. | 2·04 | ... | ,, . | Seaforde ..... | 2·85 | 103 |
| ,, . | Arisaig, Faire-na-Sguir | 3·07 | ... | ,, . | Donaghadee, C. Stn.... | 1·78 | 76 |
| ,, . | Fort William, Glasdrum | 3·62 | ... | ,, . | Banbridge, Milltown... | 2·93 | 114 |
| ,, . | Skye, Dunvegan..... | 3·84 | ... | *Antr* . | Belfast, Cavehill Rd.... | 3·15 | ... |
| ,, . | Barra, Skallary ..... | 3·23 | ... | ,, . | Aldergrove Aerodrome | 2·66 | 110 |
| *R & C* . | Alness, Ardross Castle | 2·63 | 116 | ,, . | Ballymena, Harryville | 2·85 | 98 |
| ,, . | Ullapool ..... | 3·54 | 150 | *Lon* . | Londonderry, Creggan | 3·17 | 112 |
| ,, . | Achnashellach ..... | 4·30 | 108 | *Tyr* . | Omagh, Edenfel..... | 2·43 | 86 |
| ,, . | Stornoway ..... | 2·05 | 88 | *Don* . | Malin Head..... | 1·83 | ... |
| *Suth* . | Lairg ..... | 2·03 | 97 | ,, . | Milford, The Manse ... | 2·70 | 98 |
| ,, . | Tongue ..... | 1·93 | 94 | ,, . | Killybegs, Rockmount. | 3·62 | 95 |

## Climatological Table for the British Empire, January, 1933

| STATIONS | PRESSURE | | TEMPERATURE | | | | | | | Relative Humidity | Mean Cloud Am'nt | PRECIPITATION | | | BRIGHT SUNSHINE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean of Day M.S.L. | Diff. from Normal | Absolute | | Mean Values | | | | Mean Wet Bulb | | | Am'nt | Diff. from Normal | Days | Hours per day | Percentage of possible |
| | | | Max. | Min. | Max. | Min. | ½ max. and min. | Diff. from Normal | | | | | | | | |
| | mb. | mb. | °F. | °F. | °F. | °F. | °F. | °F | °F. | % | 0—10 | in. | in. | | | |
| London, Kew Obsy. .. | 1020·8 | + 3·2 | 53 | 23 | 41·5 | 33·1 | 37·3 | — 1·6 | 35·4 | 88 | 7·5 | 1·34 | — 0·42 | 15 | 1·3 | 15 |
| Gibraltar..... | 1018·8 | — 2·7 | 66 | 42 | 61·6 | 47·8 | 54·7 | — 0·2 | 48·4 | 86 | 5·3 | 14·94 | + 10·30 | 17 | .. | .. |
| Malta ..... | 1014·6 | — 2·4 | 65 | 43 | 59·6 | 49·7 | 54·7 | — 0·6 | 49·6 | 76 | 6·8 | 6·98 | + 3·77 | 21 | 4·9 | 50 |
| St. Helena ..... | 1011·9 | — 0·7 | 72 | 56 | 68·0 | 59·8 | 63·9 | — 0·1 | 60·9 | 93 | 8·5 | 1·94 | .. | 16 | .. | .. |
| Freetown, Sierra Leone | 1012·8 | + 2·0 | 93 | 69 | 87·2 | 74·5 | 80·9 | — 0·4 | 75·5 | 90 | 3·9 | 0·00 | — 0·41 | 0 | .. | .. |
| Lagos, Nigeria ..... | 1009·7 | + 0·1 | 92 | 66 | 87·3 | 74·6 | 80·9 | 0·0 | 74·1 | 86 | 3·8 | 4·93 | + 3·89 | 3 | 6·0 | 51 |
| Kaduna, Nigeria .... | 1011·4 | — 3·3 | 96 | 54 | 90·9 | 61·6 | 76·3 | + 2·9 | 58·5 | 42 | 2·4 | 0·22 | + 0·22 | 1 | 8·2 | 71 |
| Zomba, Nyasaland .. | 1007·7 | + 0·3 | 86 | 62 | 78·6 | 64·7 | 71·7 | — 1·1 | 67·7 | 81 | 8·6 | 10·86 | — 0·24 | 24 | .. | .. |
| Salisbury, Rhodesia .. | 1009·0 | — 1·6 | 82 | 54 | 76·2 | 60·2 | 68·2 | — 1·5 | 63·2 | 81 | 8·5 | 10·18 | + 2·86 | 20 | 4·2 | 32 |
| Cape Town..... | 1012·6 | — 0·8 | 86 | 55 | 79·8 | 60·9 | 70·3 | + 0·4 | 60·9 | 62 | 2·6 | 0·68 | 0·00 | 3 | .. | .. |
| Johannesburg ..... | 1008·7 | — 0·4 | 90 | 47 | 80·1 | 55·7 | 67·9 | + 1·2 | 57·7 | 61 | 4·4 | 2·38 | — 3·79 | 13 | 8·9 | 65 |
| Mauritius ..... | 1012·3 | + 0·4 | 93 | 67 | 86·9 | 72·7 | 79·8 | + 0·5 | 75·6 | 69 | 6·4 | 5·22 | — 2·54 | 19 | 8·7 | 66 |
| Calcutta, Alipore Obsy. | 1015·9 | + 0·7 | 83 | 48 | 76·3 | 54·2 | 65·3 | — 1·3 | 54·1 | 82 | 2·0 | 0·78 | + 0·36 | 2* | .. | .. |
| Bombay ..... | 1012·9 | — 0·7 | 91 | 57 | 85·6 | 67·5 | 76·5 | + 1·0 | 65·8 | 73 | 2·1 | 0·00 | — 0·10 | 0* | .. | .. |
| Madras ..... | 1013·8 | — 0·3 | 87 | 65 | 84·1 | 69·3 | 76·7 | + 0·5 | 71·2 | 82 | 5·3 | 0·00 | — 1·14 | 0* | .. | .. |
| Colombo, Ceylon .... | 1010·3 | — 0·5 | 90 | 68 | 85·7 | 73·0 | 79·3 | — 0·2 | 74·5 | 80 | 6·5 | 6·57 | + 3·32 | 17 | 5·1 | 43 |
| Singapore ..... | 1009·6 | — 0·8 | 90 | 71 | 85·2 | 72·5 | 78·9 | — 0·8 | 75·3 | 85 | 7·0 | 11·02 | + 2·13 | 22 | 4·7 | 39 |
| Hongkong ..... | 1021·7 | + 2·0 | 73 | 41 | 60·9 | 51·5 | 56·2 | — 4·0 | 50·8 | 73 | 9·0 | 0·48 | — 0·84 | 6 | 2·4 | 22 |
| Sandakan ..... | 1010·1 | .. | 87 | 73 | 85·4 | 75·1 | 80·3 | + 0·5 | 76·4 | 82 | 7·6 | 17·64 | — 1·76 | 21 | .. | .. |
| Sydney, N.S.W. .... | 1009·7 | — 2·7 | 101 | 55 | 76·3 | 65·1 | 70·7 | — 0·9 | 65·5 | 72 | 6·9 | 6·46 | + 2·79 | 16 | 6·4 | 45 |
| Melbourne ..... | 1011·2 | — 1·7 | 96 | 47 | 76·2 | 56·1 | 66·1 | — 1·3 | 58·0 | 60 | 6·9 | 1·74 | — 0·15 | 8 | 6·2 | 43 |
| Adelaide ..... | 1011·8 | — 1·2 | 103 | 50 | 80·3 | 60·2 | 70·3 | — 3·6 | 59·5 | 47 | 7·2 | 2·25 | + 1·53 | 9 | 7·2 | 51 |
| Perth, W. Australia .. | 1012·1 | — 0·4 | 103 | 57 | 83·7 | 64·9 | 74·3 | + 0·5 | 62·4 | 49 | 4·3 | 0·57 | + 0·23 | 3 | 10·2 | 73 |
| Coolgardie ..... | 1011·7 | + 0·2 | 103 | 50 | 90·7 | 60·0 | 75·3 | — 2·1 | 61·3 | 47 | 1·9 | 0·11 | — 0·35 | 2 | .. | .. |
| Brisbane ..... | 1009·9 | — 1·4 | 94 | 65 | 85·9 | 69·5 | 77·7 | + 0·5 | 71·1 | 66 | 6·1 | 10·01 | + 3·51 | 14 | 8·9 | 65 |
| Hobart, Tasmania.... | 1010·1 | — 0·2 | 81 | 44 | 66·6 | 51·1 | 58·9 | — 3·1 | 52·6 | 62 | 7·0 | 2·18 | + 0·35 | 19 | 7·3 | 49 |
| Wellington, N.Z. .... | 1011·6 | — 1·7 | 82 | 46 | 69·8 | 55·7 | 62·7 | + 0·2 | 59·0 | 73 | 6·6 | 2·07 | — 1·26 | 13 | 8·1 | 55 |
| Suva, Fiji ..... | 1007·2 | — 0·3 | 96 | 73 | 88.1 | 75·0 | 81·5 | + 1·6 | 75·4 | 75 | 5·7 | 4·84 | — 6·59 | 19 | 7·6 | 58 |
| Apia, Samoa ..... | 1006·7 | — 1·2 | 89 | 71 | 85·1 | 74·9 | 80·0 | + 1·0 | 76·7 | 82 | 6·7 | 23·01 | + 5·96 | 20 | 5·2 | 41 |
| Kingston, Jamaica .. | 1014·2 | — 0·9 | 90 | 65 | 85·9 | 67·7 | 76·8 | 0·0 | 65·2 | 81 | 3·8 | 0·67 | — 0·29 | 2 | 8·2 | 73 |
| Grenada, W.I. ..... | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Toronto ..... | 1014·8 | — 3·1 | 55 | 5 | 40·0 | 27·2 | 33·6 | +11·4 | 29·0 | 78 | 6·7 | 1·41 | — 1·38 | 8 | 3·0 | 32 |
| Winnipeg ..... | 1012·2 | — 8·7 | 33 | —31 | 11·9 | —7·3 | 2·3 | + 6·2 | .. | .. | 5·7 | 0·00 | — 0·91 | 0 | 2·3 | 27 |
| St. John, N.B. ..... | 1013·7 | — 1·8 | 47 | 0 | 35·2 | 18·3 | 26·7 | + 7·5 | 23·7 | 82 | 6·3 | 2·41 | — 2·39 | 12 | 3·1 | 34 |
| Victoria, B.C. ..... | 1009·9 | — 6·1 | 49 | 29 | 42·3 | 35·9 | 39·1 | + 0·1 | 33·5 | 56 | 7·3 | 4·95 | + 0·41 | 21 | 2·1 | 24 |

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.